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Performance of Gravity Thickener in Cairo WWTP

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Abstract*—Gravity thickeners most commonly used in wastewater treatment plants in Egypt. Gravity thickeners designed so as sedimentation happens due to physical reactions only, but what actually happens is that due to other incomprehensible reactions the sedimentation efficiency is affected. The main goal of the present work is to study the gravity thickener behavior and determine the affecting factors on its gravity thickening working. Determine the best mixing ratio between primary & secondary sludge for thickener from different three wastewater treatment plants in in Egypt (El Berkah WWTP, Zenein WWTP & El- Gabal Al. Asfar contract (16)).*

The experimental work was conducted from the primary sludge was the sludge resulting from primary sedimentation tank of each WWTP while the waste activated sludge is the sludge resulting from final sedimentation tank. The laboratory experiment was mixing the two different types of with different ratios (starting from the set value of El- Gabal Al. Asfar contract (16) which was (30 % Primary sludge (PS) + 70% Waste activated sludge (WAS)) in the blending tank) and different retention times from (0 to 40 hour). The lab experimental results show that the best mixing ratio between primary sludge (PS) and waste activated sludge (WAS) is (40 % PS + 60 % WAS). From TSS curves the best mixed ratio between primary sludge (PS) and waste activated sludge (WAS) with the gravity thickener is found (40 % PS+ 60 % WAS). This was because TSS curve shows that the slope of the line simulates results of mixed ratio (40 % PS + 60 % WAS) is the highest slope compared with the other mixed ratios lines and this slope simulates the thickening concentration ratio. From the batch-scale lab experiments also find, the big effect of biological action was presentable after 16 hrs must be taken into consideration when thickener designing and it prove that hydrolysis phase by anaerobic action can be happened from start settling by gravity thickener depends on the sludge characteristics and sludge age.

***Keywords*—** *Sludge thickening ; gravity thickening; BOD_5; COD;TSS; VSS; organic matter; anaerobic action ; complete treatment.*

I. INTRODUCTION

In the wastewater treatment; particularly domestic sewage, sludge production performs an important session that incorporates the stabilization/disposal of suspended solids encountered. Sludge treatment may evolve thickening, digestion, dewatering, and disposal. Sludge thickening is the most process used for solids concentrating before digestion and/or dewatering.

Sludge thickening is theoretically a physical process to precipitate the inherent suspended solids within a settling tank to induce a condense sludge strata in the tank hopper located at the bottom. The condensed sludge is highly recommended to reduce the volume of the onward treatment unit; e.g. digesters or dewatering facilities.

However the sludge thickening process has been induced to physical separation of suspended solids, many maladies have been reported and dictated about the un-proper performance of the solids separation (solids concentrating) that imposes serious mal-functioning of the thickening concept. Among the reported phenomenon are bad settling, solids wash- out & sludge souring. In Egypt, these features have been reported for thickeners in some treatment plants; e.g. El. Berkah & El-Ramla WWTPs in Qalyoubia Governorate.

As the design results should comply with the operating conditions to get-in the required process efficiency, the design procedures should include all parameters affecting the inherent mechanism of the process. Some researches and investigations have been conducted since few years in a limited range of sludge sources to adopt the reasons leading to the drop of the thickening process efficiency. They can monitor some reasons but still these reasons need more investigation and study.

Study Objective

Study the effects that are leading to deviation of performance of gravity thickening running under normal conditions in Cairo, Egypt.

This was made through a lab experimental work on the sets illustrated in Figure (1) on different sludge type (primary sludge, waste activated sludge & mixing sludge between them with different mixing ratios) from three different WWTP which are El Berkah WWTP, Zenein WWTP & El- Gabal Al-Asfar contract (16).

Figure (1) shows the batch system that operated according to the following scheme:

- Collect the sludge samples from the WWTP.
- Put 6 backers of volume one liter for each type of sludge (primary sludge, waste activated sludge, mixed sludge (30% primary sludge + 70 % waste activated sludge).
- Put 6 flasks for gas production measurement of volume one liter for each type of sludge (primary sludge, waste activated sludge, mixed sludge (30% primary sludge + 70 % waste activated sludge).
- Start the operation in the same time.
- The temperature of the sample has the same temperature of the laboratory which is equal 20 C°.
- The sample volume will be 100 mm. Take it at the bottom.

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- For the first backer for each type for sludge measure the parameters (BOD_5,COD, TSS, and VSS) .
- For the second backer for each type for sludge measure the parameters (BOD_5, COD, TSS, VSS & gas production) after 16 hrs.
- The measuring of the same parameters after third, fourth and fifth backer at different time (18 hrs, 24 hrs, 40 hrs) from the start of the experiment.
- Taking the same sludge: the primary and the waste activated sludge from the same WWTP and mixed them according to the following ratio:

✓ 40 % PS + 60%WAS	✓ 22 % PS + 78%WAS
✓ 37 % PS + 63%WAS	✓ 20 % PS + 80%WAS
✓ 35 % PS + 65%WAS	✓ 17 % PS + 83%WAS
✓ 32 % PS + 68%WAS	✓ 15 % PS + 85%WAS
✓ 27 % PS + 73%WAS	✓ 12 % PS + 88%WAS
✓ 25 % PS + 75%WAS	✓ 10 % PS + 90%WAS

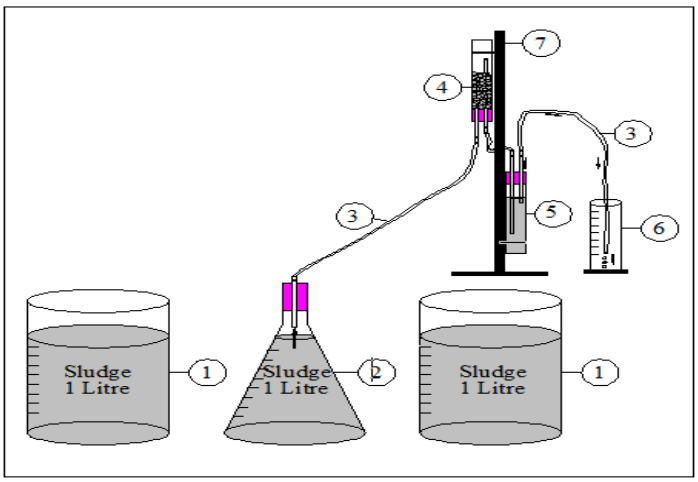

Figure (1) The Lab Batch Component System

- In one run contains (Primary Sludge only + Waste Activated Sludge only + (one mixing in the previous mentioned) of the same WWTP.
- Measured the same parameter of the sample.

The measured parameter as follows:

for sludge

(Biochemical oxygen demand (BOD_5), Chemical oxygen demand (COD), Total suspended solids (TSS) & Volatile suspended solids (VSS)).

for gases (Volume of gases).

Gases produced from action are CH_4, CO_2, N_2, H_2, H_2S, water vapor, and other gases. When the lab experiments operation to produce the previous gasses and pass through plastic pipe from flask to glass tubes filled with sodium hydroxide for moisture absorption of the produced gas except the CH_4. The CH_4 gas passes through the plastic tube to glass tubes filled with water and the CH_4 push the water. The gas productions (CH_4) from the lab experiments estimated by measuring the displacement of water in the glass tubes and record the height of water in the graduated cylinder.

- Repeat the previous steps with the sludge from the second wastewater treatment plant (Zenein WWTP) and sludge from third wastewater treatment plant El- Gabal Al. Asfar contract (16).
- Samples analyzed for all parameters (BOD_5, COD, TSS and VSS). All analysis made according to Standard Methods.

II. RESULTS

The lab experimental results were collected sludge from different three wastewater treatment plant as following:

1. *Results for Sludge from El-Berkah Wwtp*

Figures from (2 to 5) show results for sludge collected from El-Berkah WWTP.

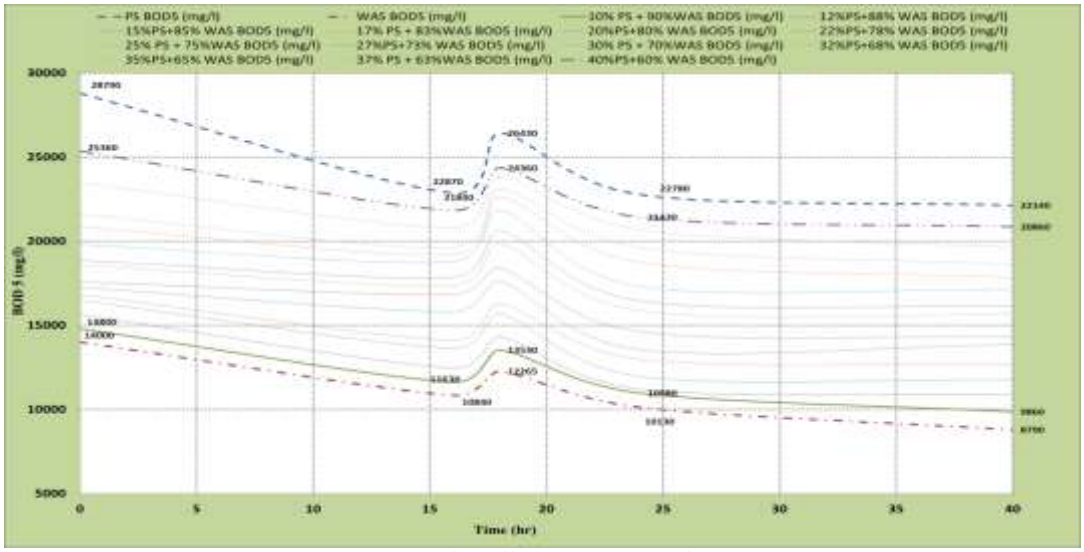

Figure (2) BOD_5 versus Time for Different Sludge Types from El Berkah WWTP.

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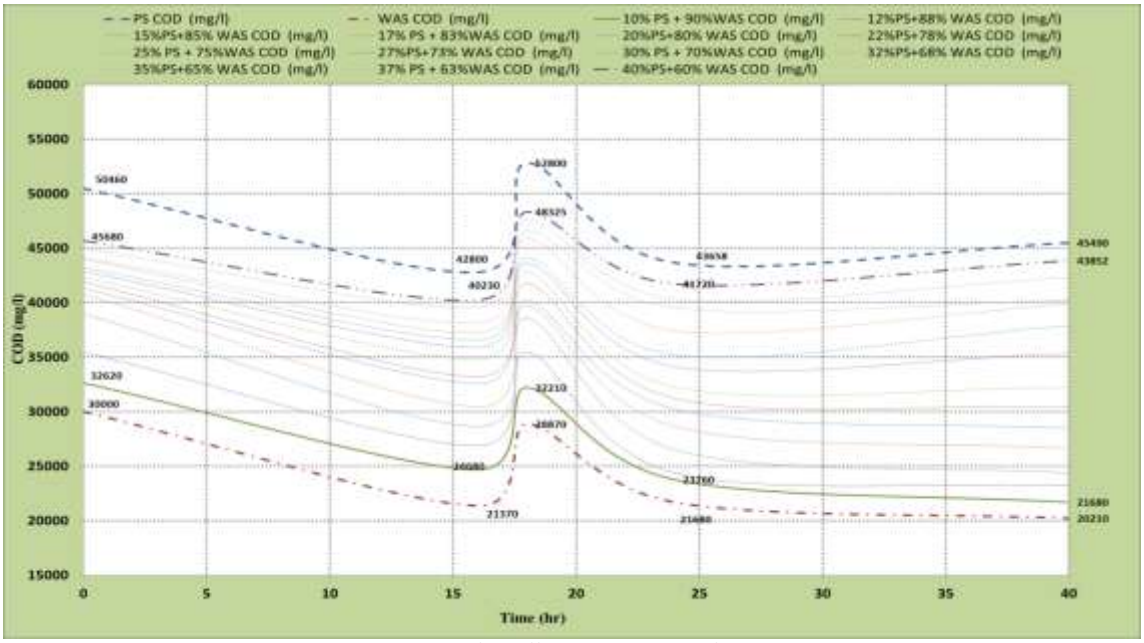

Figure (3) COD versus Time for Different Sludge Types from El Berkah WWTP.

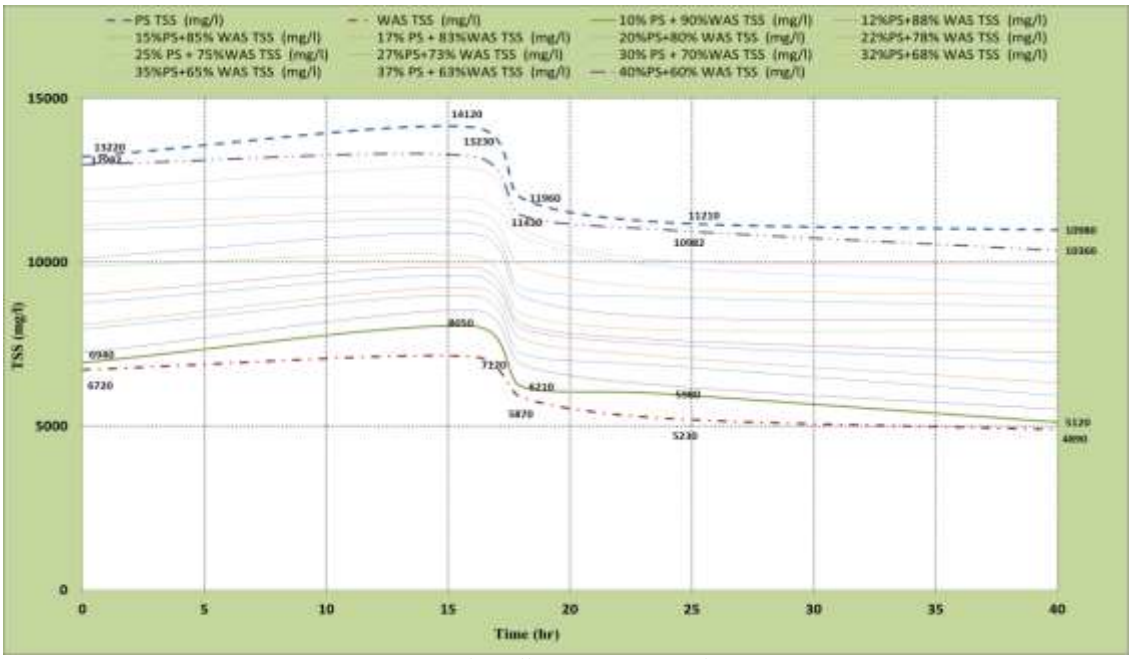

Figure (4) TSS versus Time for Different Sludge Types from El Berkah WWTP.

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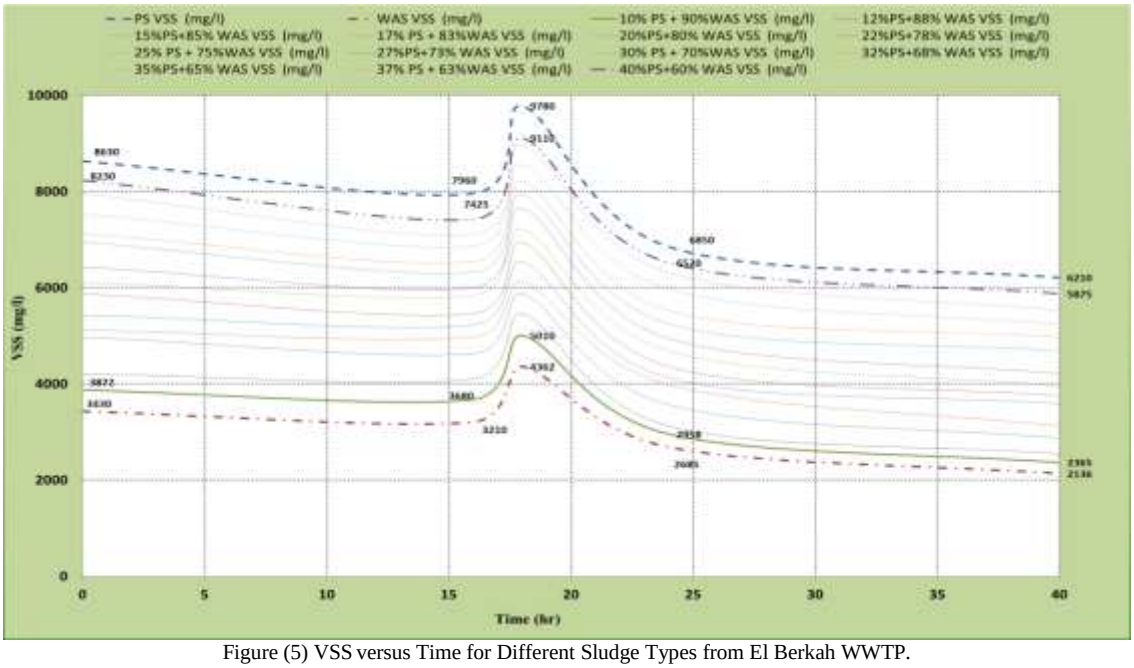

Figure (5) VSS versus Time for Different Sludge Types from El Berkah WWTP.

2. Results With Sludge From Zenein WWTP.

Figures from (6 to 9) show results when sludge collected from Zenein WWTP.

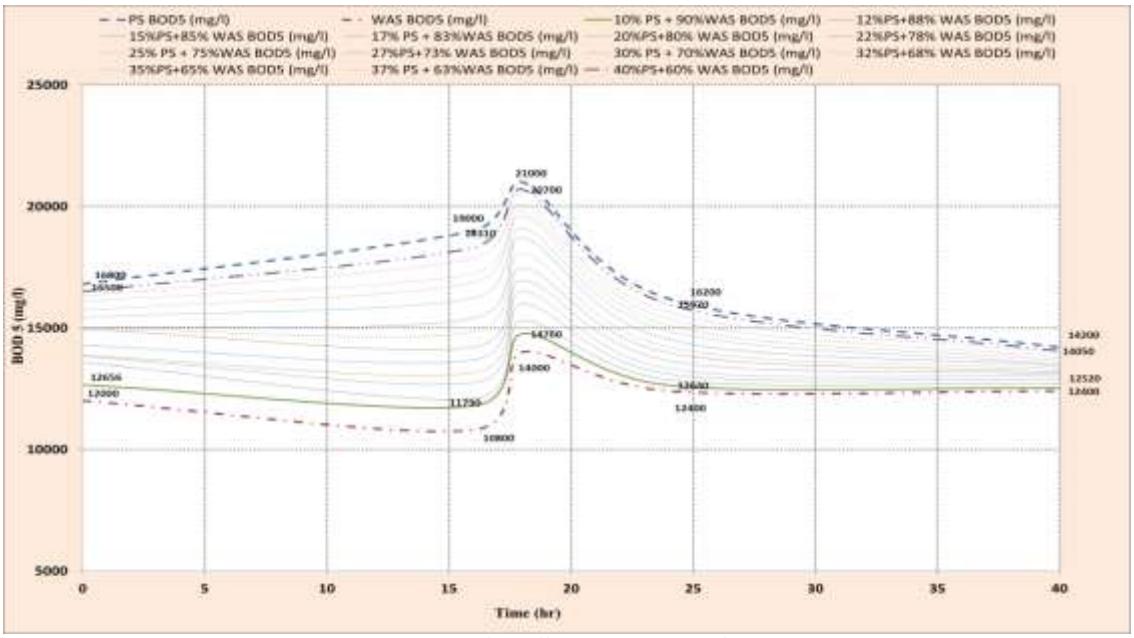

Figure (6) BOD_5 versus Time for Different Sludge Types from Zenein WWTP.

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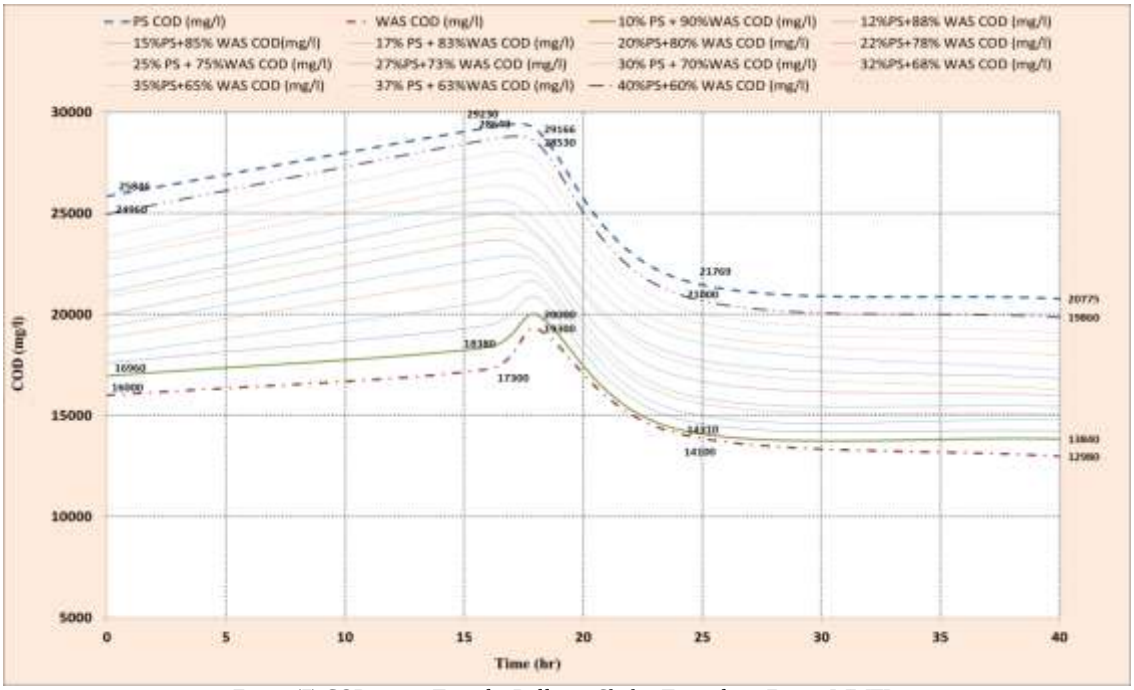

Figure (7) COD versus Time for Different Sludge Types from Zenein WWTP.

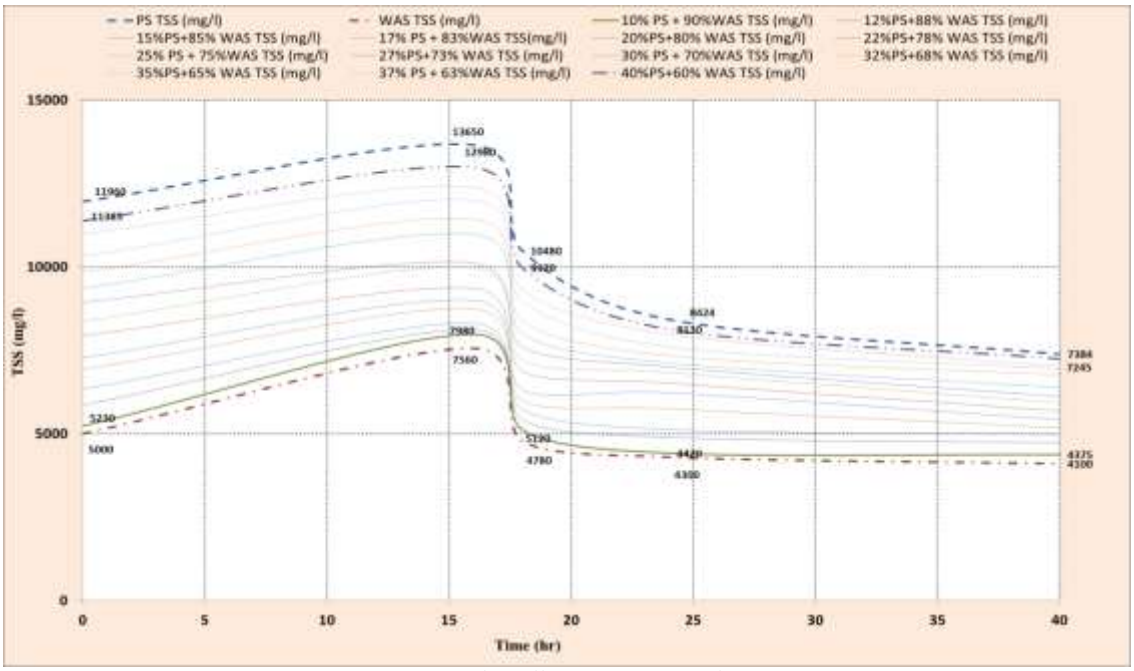

Figure (8) TSS versus Time for Different Sludge Types from Zenein WWTP.

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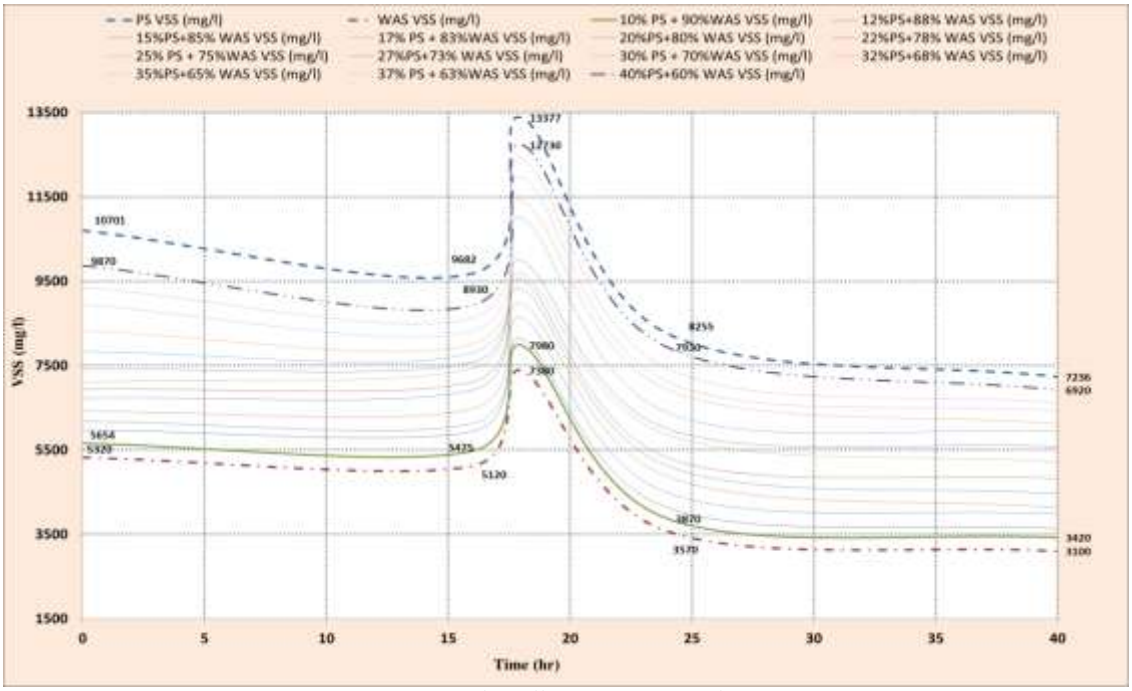

Figure (9) VSS versus Time for Different Sludge Types from Zenein WWTP.

3. *Results with Sludge from El- Gabal Al. Asfar Contract (16)) WWTP*

Figures from (10 to 13) show results when sludge collected from El-Gabal AL Asfar Contract (16) WWTP

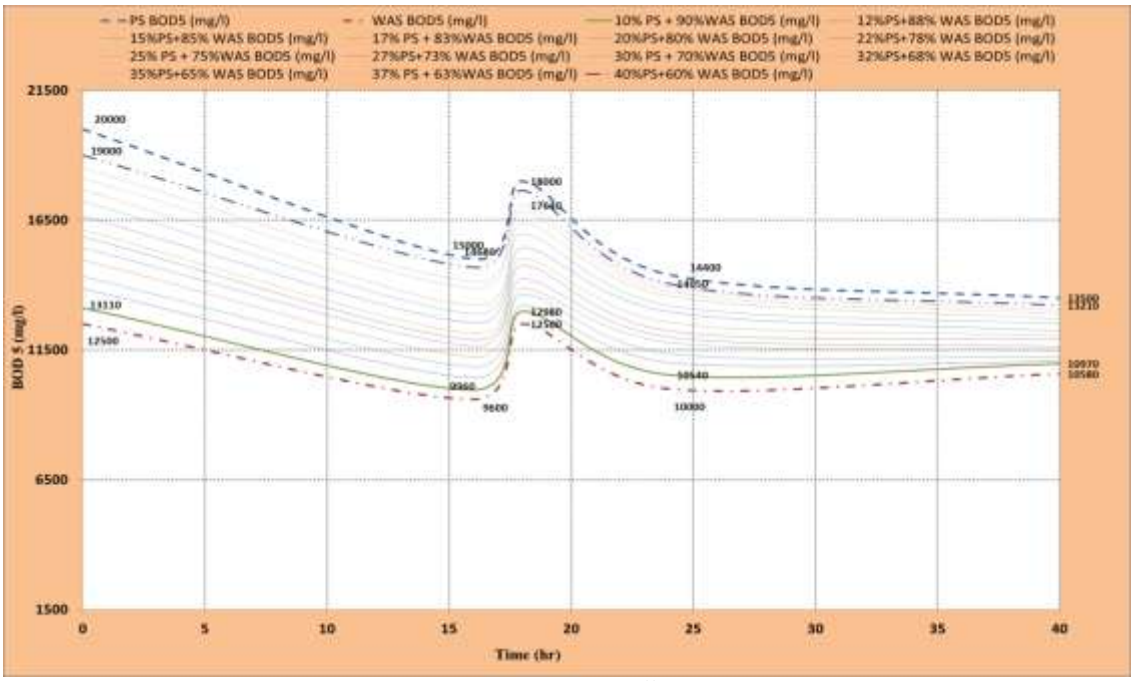

Figure (10) BOD_5 Versus Time For Different Sludge Types
From El-Gabal Al-Asfar (contract (16)) WWTP.

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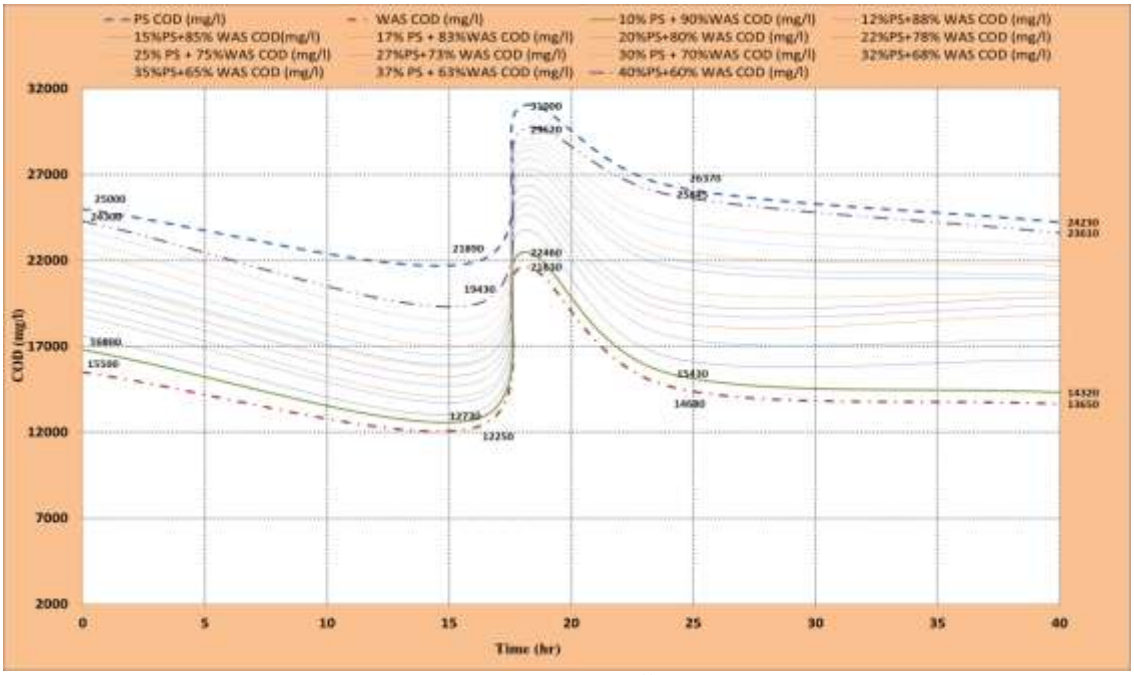

Figure (11) COD Versus Time For Different Sludge Types
From El-Gabal Al-Asfar (contract (16)) WWTP.

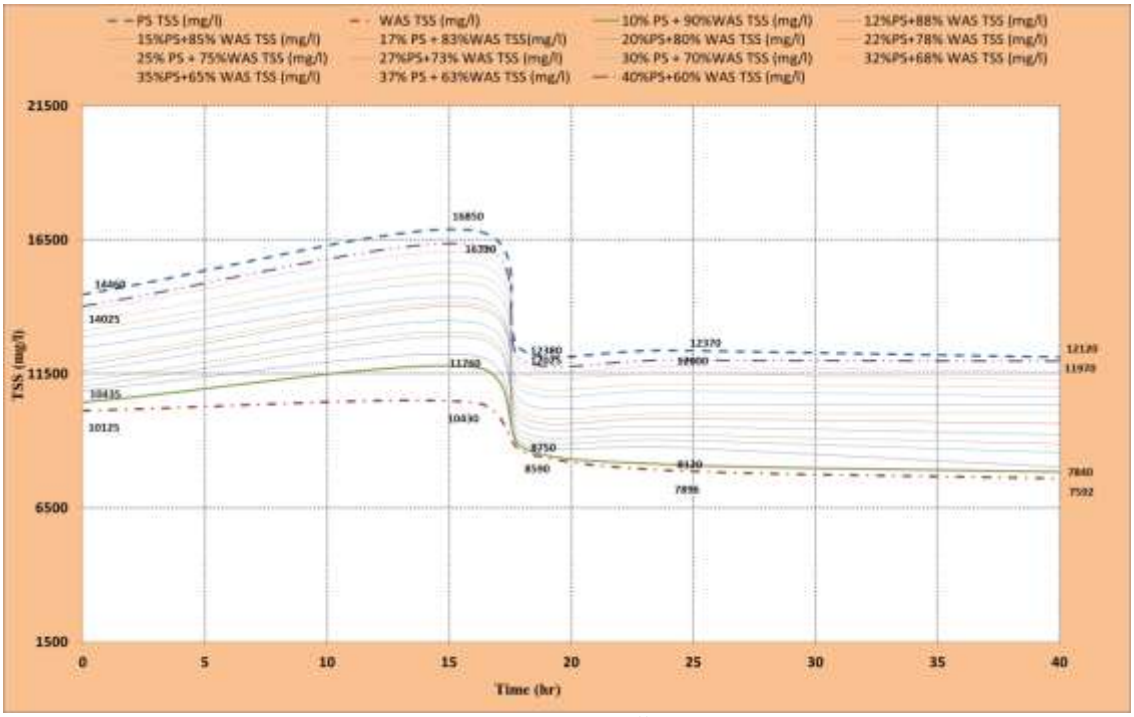

Figure (12) TSS Versus Time For Different Sludge Types
From El-Gabal Al-Asfar (contract (16)) WWTP.

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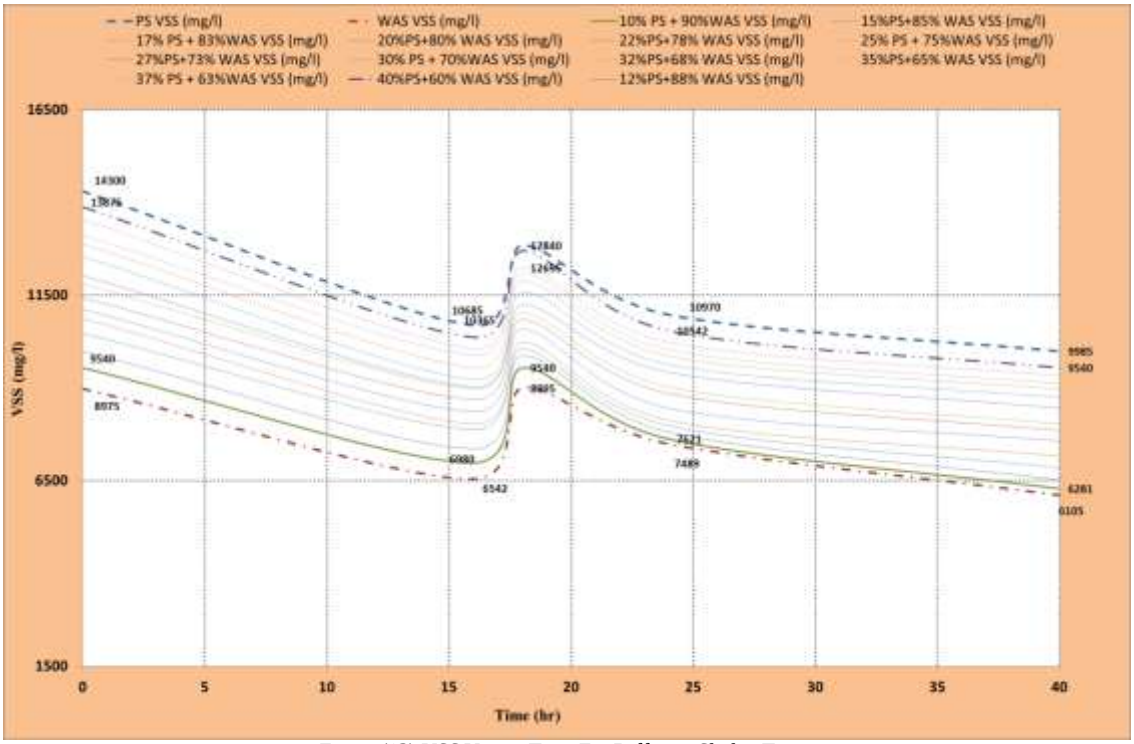

Figure (13) VSS Versus Time For Different Sludge Types
From El-Gabal Al-Asfar (contract (16)) WWTP.

III. DISCUSSION

From the previous figures of the different sludge, types that collected from three different wastewater treatment plants in Cairo, Egypt the following notes could be raised:

Discussion of Results of Sludge from Both El Berkah & El-Gabal Al-Asfar Contract (16) WWTP

The results of both plants were almost of the same behavior that leads to the same discussion for both of them as follows:

1. Figures (4) & (12) show, TSS values increased when the retention times increased from (0 hrs to 16 hrs) it means the sludge thickening was happened at this time due to physical action. Then TSS values decreased when retention times increased from (16 hrs to 18 hrs) due to the anaerobic bacterial action started to appear that destructed some of organic settled solids and produced some gases caused floating to the thickened sludge and made a big sudden decrease in its TSS values. This phenomenon called break down phenomena. While TSS values slowly decreased when the retention times increased from (18 hrs to 40 hrs) because the gentle mixing destruct the contained floated sludge strata and gases escaped alone but the solids takes a long period to return back to the thickened sludge as shown in the time (18 hrs to 40 hrs).
2. Figures (2) & (10) illustrated the decrease of BOD_5 values with the increase of retention times from (0 hrs to 16 hrs). This was due to the bacteria work on the soluble fractions only. Therefore, these soluble fractions are taken into account when BOD_5 is measured for samples. On the other hand, with the increase of retention times from (16 hrs to 18 hrs) the BOD_5 values increased. That is because the hydrolysis phase happened as result of the anaerobic action inside backer so that the soluble fractions increased when conversion from suspended fractions to soluble fractions by hydrolysis phase making the appearance of the break down phenomena. In addition, the bacteria decay due to absence of enough organic matters could be another reason for such phenomena for producing the organic matters that cause the increase of soluble fractions, therefore, the BOD_5 increase at retention time (16 hrs -18 hrs). On the other hand, when retention times increased from (18 hrs to 40 hrs) the BOD_5 values decreased because of the bacteria oxidize the organic matters until the end of the experiment time (40 hrs).
3. From Figures (3) & (11), the COD values takes the same behavior as BOD_5.
4. Also the same figures show that COD values of primary sludge are the highest compared with the mixing sludge and the waste activated sludge.
5. From figures (5) & (13), the VSS values decreased with the retention time increase from (0 hrs to 16 hrs) for the time was not enough for the anaerobic action to take place that caused the bacterial decay. But, after the anaerobic action start after 16 hours the VSS increased till its optimum with the availability of organics which consumed during 2 hrs then the action decreased due to the absence of organics and both the BOD_5 & the VSS decreased. Also, VSS values of primary sludge are the highest than mixing sludge and waste activated sludge.

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6. Amount of gas production is very low therefore, it melted in water and it cannot be measured from the three-wastewater treatment plants.

Discussion of Results of Sludge from Zenein WWTP

1. Figure (8) illustrates that TSS values increase when the retention times increase from (0 hrs to 16 hrs) it means the sludge thickening was happened at this time due to physical action, then TSS values decrease when retention times increase from (16 hrs to 18 hrs) because the anaerobic bacterial action started to appear that produces some gases caused floating to the thickened sludge and make a big sudden decrease in its TSS values. This phenomenon is called break down phenomena. TSS values decrease when the retention times increase from (18 hrs to 40 hrs) because the gentle mixing destruct the contained floated sludge strata and gases escaped alone but the solids takes a long period to return back to the thickened sludge as shown in the time (18 hrs to 40 hrs).
2. Results in Figure (6) show BOD_5 values increased with the increase of retention times from (0 to 18 hr) making long breakdown phenomena. This phenomena could be happened due to even the hydrolysis phase that happened with the anaerobic action appeared causing increasing of soluble fractions inside backer, or the lack of organic matters in the backer that caused bacterial decay produce organic matters which result the increase of soluble fractions, therefore the BOD_5 increase at retention time (0-18 hour).
3. Then BOD_5 values decreased after 18 hr until the end of experiment time 40 hr that was due to the bacterial destruction of the organic matters.
4. BOD_5 values of primary sludge are highest than its values of mixing sludge and of waste activated sludge.
5. From Figure (7) the COD values resulted the same behavior as BOD_5 values in all cases.
6. VSS decreased due to the retention time from (0 hrs to 16 hrs) was not enough for the anaerobic action to take place that caused the bacteria decayed. And when the anaerobic action start after 16 hours the VSS increased till its optimum with the availability of organics which consumed during 2 hrs then the action decreased due to the absence of organics and both the BOD_5 & the VSS decreased.
7. Amount of gas production is very low therefore, it melted in water and it cannot be measured from the three-wastewater treatment plants.

IV. CONCLUSIONS

From all the previous work, the study could conclude the following results:

1. The results of this work simulates the all-municipal wastewater treatment plants for cities whose industrial wastewater ratio is range from (15-25) %.
2. According to greater Cairo wastewater treatment plants the best mixing ratio between primary and waste activated sludge is (40% PS + 60%WAS) for thickener efficiency, this could be guide ratio for Egyptian municipal wastewater treatment plant in big cities.
3. The biological action that takes place in the thickener after 16 hours retention time has high effect on the thickener efficiency.
4. The adaption of the mixed ratio of various sludge entering the gravity thickener represents one of a major parameters and factors that control the correct performance of the thickening process. This technique although conflicts the hydraulic load of the thickener should be applied for the correct performance of the thickening process. Accordingly, the hydraulic load of the thickener should be revised to comply with this technique.
5. The Thickener performance shows physical reaction up to 16 hours followed by biological reaction mixed with the physical up to 40 hours which illustrates the need to review all the designs criteria for such tank and enter the effect of biological action into consideration.

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